Microplastics in freshwaters: are benthic invertebrates at risk?

Carlos JM Silva[1],

Carlos Gravato[2], João LT Pestana[1]

[1] Department of Biology & CESAM, University of Aveiro)

[2] Department of Biology & CESAM, Faculty of Sciences, University of Lisbon)

Abstract

Microplastics contamination is an increasing environmental problem in freshwater ecosystems, with environmentally consequences as severe as in marine environments. However, studies on the ecological impact of such particles in these ecosystems remain scarce.

Here, we show that sediments contaminated with polyethylene microbeads (sized 48µm) led to a decrease in the growth and development of the dipteran C. riparius, which led to a delay in emergence of adult insects. Furthermore, a 48h exposure triggered an activation of immune system, induced oxidative damage, and altered energy metabolism.

These findings highlight the potential deleterious effects of small sized microplastics (<50µm), at environmental relevant concentrations (1-2 g MPs/Kg sediment w/w), to C. riparius, and eventually to other benthic macroinvertebrate species.

Future studies

To understand the extent of the impact MPs (polymer type, size, adsorbents) can induce on freshwater species, communities and ecosystems functioning, laboratory tests in combination with mesocosms assays will be conducted in order to assess stress responses at different levels of biological organization (from the cell to the ecosystem).

For more information, please visit:

www.comPETproject.ua.pt

Context

Freshwater contamination by the presence of microplastics (MPs) is an environmental urgent issue, with many studies pointing towards a significant input of of <300 µm sized particles particularly polyethylene microbeads (PE), that are incorporated in many personal care products. MP's are likely to sink and accumulate in freshwaters sediments thus affecting benthic communities similarly to what is observed in marine biota.

Apart from the physical effects related to the ingestion of MPs, cellular and sub-cellular/ biochemical stress responses induced by the release of MPs hazardous components or adsorbents are also to be expected. Up to now, there is limited information regarding the effects of MPs on life-history traits and biochemical responses of freshwater benthic macroinvertebrates, which are used as bioindicators of the ecological status of freshwaters. These macroinvertebrates which are prey for many invertebrate and vertebrate species, live in close contact with sediments and are likely to ingest such MP's. Negative impacts on freshwater benthic macroinvertebrates (and communities) are thus early warning indicators of adverse effects of plastic pollution on ecosystem functioning.

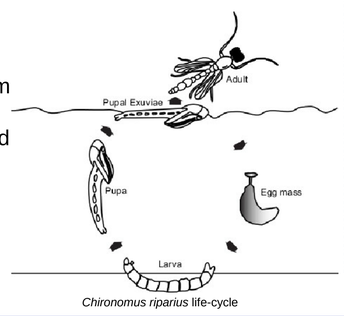
Materials and Methods

Test species: *Chironomus riparius* (Diptera, detritivorous, benthic, model organism in ecotoxicology)

Sediment: natural river sediment previously burnt, particles size < 1mm

MPs concentrations: 0 - 1.25 - 2.5 - 5 - 10 - 20 g of PE 40-48µm spiked directly into sediment (g PE/kg sediment)

Test conditions: 20±1ºC; air supply, 8.5<pH<7.2, [oxygen]>60%



Chironomus riparius life-cycle

Life-history traits:

- Larval Growth → 10-days exposure
- Emergence → 28-days exposure

OECD Guideline 218

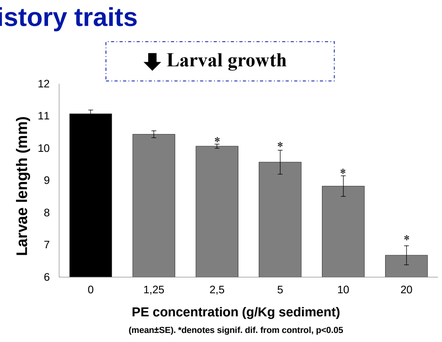
Biochemical responses:

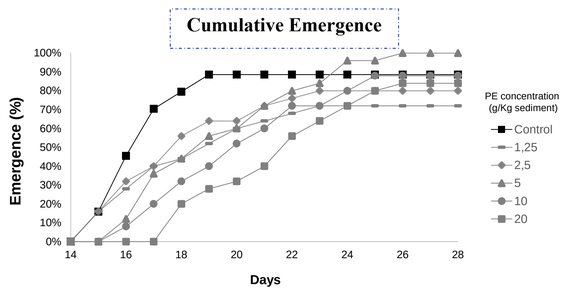
- Immune response (PO)
- Oxidative damage (LPO)
- Biotransformation (GST)
- Antioxidant defenses (CAT)
- Energy reserves (Lipids, Carbohydrates, Protein)
- Energy consumption (Electron Transport System Activity)

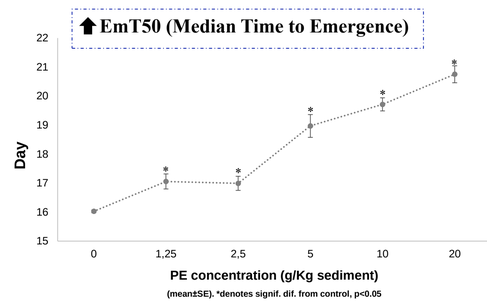
48h exposure using L4 larvae

Results

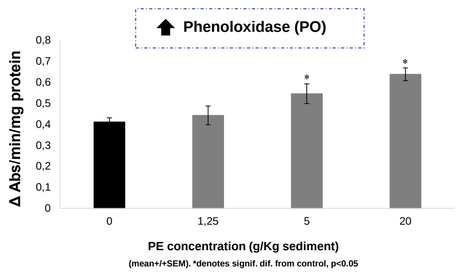
Life-history traits

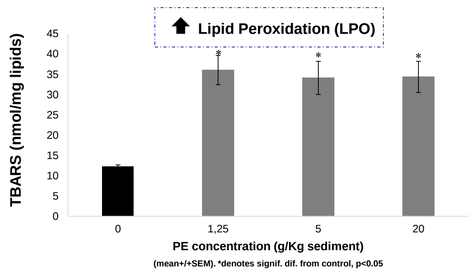


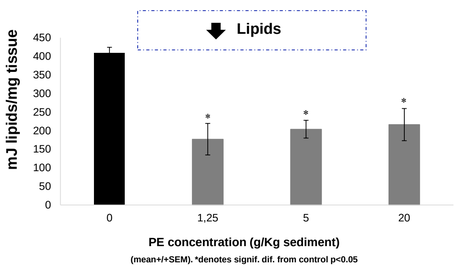


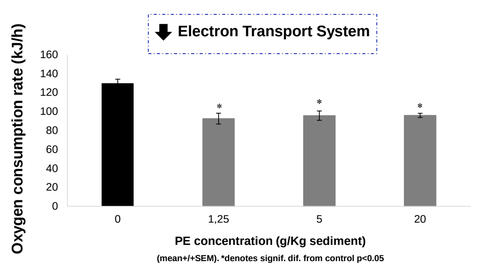


Biochemical responses

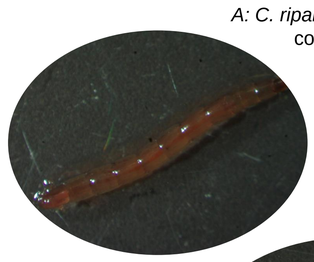








A: C. riparius larvae that grew in control conditions



B: C. riparius larvae after ingestion of PE microbeads

Conclusions

- Exposure to small-size PE microbeads (40-48µm) led to deleterious effects in *C. riparius* larval growth and development, indicating potential population-level effects.
- Exposure to PE microbeads also induced an immune response (increased phenoloxidase activity) in insect larvae, together with oxidative damage (↗lipid peroxidation), alteration in energy reserves (↘ lipid content) and impairments in energy metabolism (↘ electron transport system activity).
- These results show the deleterious effects of plastic pollution in freshwater invertebrate species, the potential for accumulation of plastics along food webs and represent a first step guiding the development of such investigations under more ecological relevant scenarios.

Cofinanciado por:

COMPETE 2020 PROGRAMA OPERACIONAL COMPETITIVIDADE E INTERNACIONALIZAÇÃO

PORTUGAL 2020

UNIÃO EUROPEIA
Fundo Europeu de Desenvolvimento Regional

FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

Thanks are due for Carlos Silva doctoral grant (SFRH/BD/128134/2016) and for the financial support to CESAM (UID/AMB/50017-POCI-01-0145-FEDER-007638), to FCT/MEC through national funds, and the co-funding by the FEDER, within the PT2020 Partnership Agreement and Compete 2020.